Operating Instructions

ZF-DUOPLAN®

Two-speed Gearbox
2K450 / 2K600

08.2013 Edition

4161 758 106c_en

Subject to alterations in design

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1 Preface

This documentation is intended for specialists who have experience to carry out maintenance and repair work.

The ZF product is documented in accordance with the design status as of the issue date.

The following safety notices are used in these operating instructions:

NOTE
Used to highlight special sequences, methods, information, etc.

CAUTION
Used when incorrect and improper operating procedures can cause damage to the product.

⚠ DANGER!
Used when due lack of care and attention can cause injury to personnel and/or damage to property.

⚠ ENVIRONMENTAL HAZARDS!
Lubricants and cleaning products must not be poured onto the ground, into groundwater or down the drain.

- Obtain and comply with the safety regulations relevant to these products issued by your local environmental authority.
- Collect used oil in a suitably large container.
- Dispose of used oil, clogged filters, lubricants and cleaning products in accordance with local environmental protection regulations.
- Always follow the instructions issued by the manufacturer when handling lubricants and cleaning products.

1.1 Safety instructions

- All persons repairing ZF units are responsible for their own work safety.
- Every applicable safety regulation and legal requirement must be complied with in order to prevent injury to personnel and/or damage to the product during the course of maintenance and repair work.
- Repair staff should familiarize themselves with these regulations before commencing work.
- Correct and proper repair of these ZF products can only be assured by appropriately trained specialists.
- The organization in charge of repairs is responsible for ensuring that such training is given.
- Read these operating instructions carefully before commencing any testing or repair work.

CAUTION
Pictures, drawings and components do not always represent the original object but are used to illustrate working procedures.

The illustrations, diagrams and parts are not drawn to scale and no assumptions should be made regarding size and weight (including within a single illustration or drawing).

Work must be performed as described in the text.

Following the completion of repair work and testing, the specialists must satisfy themselves that the product will function perfectly again.

1.2 ZF instructions

- Remove any traces of old seals or gaskets from mating faces. Use an oil stone to carefully remove any burrs or similar irregularities.
- Carefully cover or shield open gearboxes to prevent the ingress of foreign matter.

1.3 Service products

Product	Name/specification	Quantity (approx.) [dm³]	Use	Remarks
Grease	Shell Avania WR2 Fuchs Renolit CXEP2 Esso Beacon EP2		General purpose	
Gearbox oil	HLP 68 to ISO VG 68 HLP 46 to ISO VG 46	**2K450** B5: 5.1 **2K600** B5: 5.4	Gearbox oil for splash lubrication	Can also be used for recirculating lubrication and recirculating lubrication with heat exchanger
Gearbox oil	HLP 46 to ISO VG 46		Gearbox oil for recirculating lubrication	Can also be used for recirculating lubrication with heat exchanger
Gearbox oil	HLP 32 to ISO VG 32		Gearbox oil for recirculating lubrication with heat exchanger	
Gearbox oil	HLP 22 to ISO VG 22		Gearbox oil for recirculating lubrication with heat exchanger and integrated lubrication oil system	
Bonding agent (liquid seal)	Loctite 574		Sealing end cover in hub	
End disc	40 DIN 470	1	Hub sealing	Exchange after disassembling the hub

2 Application and Design

2.1 Application

The ZF-DUOPLAN two-speed gearbox is mainly used in machine tool drives.

By way of example, the gearbox can be used in turning machines (horizontal B5) or machining centers (vertical V1) thanks to its variable installation position. The gearbox is also suitable for use in many systems in which torque increase or speed reduction is required.

The gearboxes have coaxial output and are suitable for the high speeds generated in machine tool construction.

2.2 Features

- Two-speed gearboxes for AC and DC main spindle drives in machine tools
- Compact thanks to planetary design
- Flange-mountable to all AC, DC and standard motors
- High running smoothness and low-noise operation thanks to helical gearing
- Low torsional backlash
- Easy to install
- High radial forces permitted on output end
- Combined axial and radial force thanks to flexible output bearings
- High efficiency
- Electromotive gearchange

2.3 Design

The gearbox primarily comprises the following assemblies:

Connecting parts:
- Drive hub (1)
- Adapter plate (2) with radial shaft seal (3) and hub bearings (4), as necessary

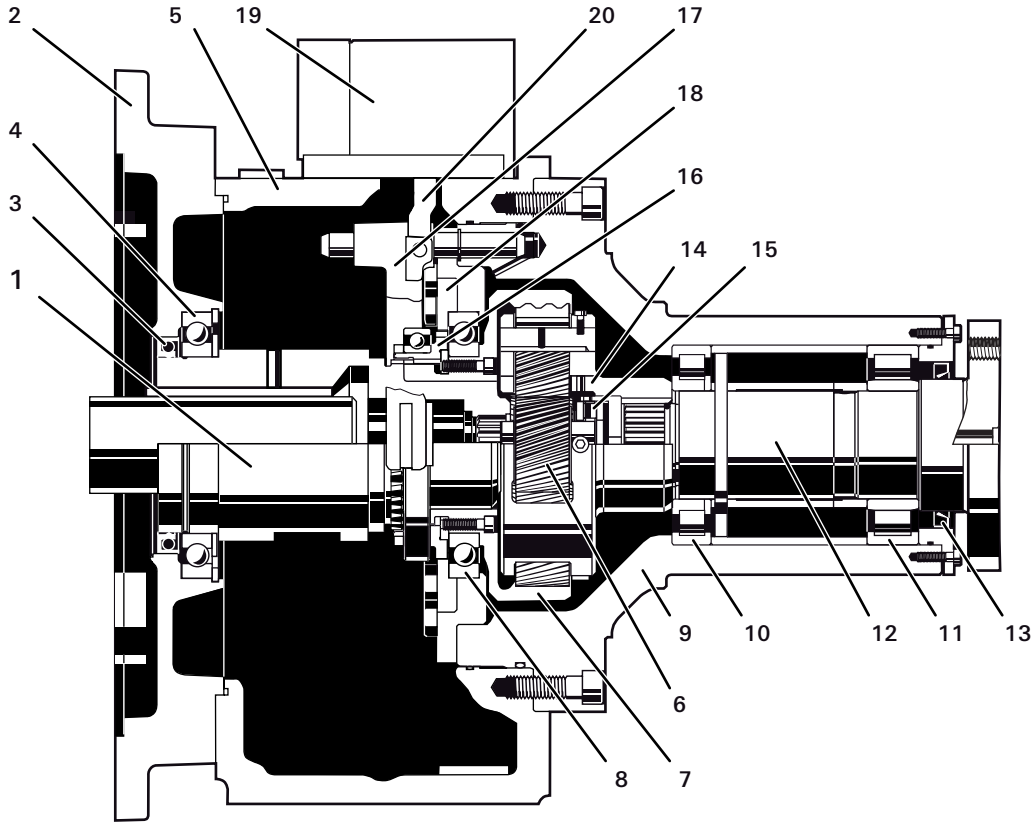
Housing:
- Gearbox housing (5)

Input:
- Sun gear (6)
- Ring gear (7)
- Ring gear bearings (8)

Output:
- Bearing housing (9)
- Output bearings (10, 11)
- Output shaft (12)
- Radial shaft seal (13)
- Planet carrier (14)
- Axial bearing with cup springs (15)

Shift mechanism:
- Sliding sleeve (16)
- Shift fork (17)
- Brake disc (18)

Shift unit:
- Shift unit (19)
- Selector finger (20)



2.4 Technical data

	2K450	2K600
Nominal power	max. 47 kW	max. 63 kW
Nominal speed	1000 rpm	1000 rpm
Max. speed in ratio i≠1 in direct drive i=1	 5000 rpm 8000 rpm	 5000 rpm 5000 rpm

NOTE
When using engine brakes/counterflow to brake the spindles (e. g. emergency stop) ensure that the moments of inertia do not exceed the admissible output torques. Braking times must be adapted accordingly.

Standard fixing dimension (in mm)
in accordance with EN 50347: 2001

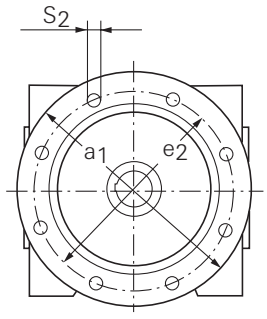
Two-speed gearbox	2K450 FF300	2K600 FF350
Motor size	160/180	180
h	160/180	180
d	55/60	60/65
l	110-0.2/ 140-0.2	140-0.2
b	250	300
e_2	350	400
s_2	18	18

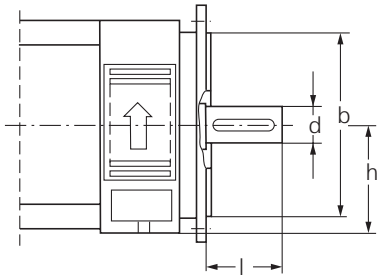
	2K450	2K600
Nominal input torque (S1)	450 Nm	600 Nm
Max. output torque (S1) for		
i = 1.00	450 Nm	600 Nm
i = 4.00	1800 Nm	2400 Nm
i = 5.00	2250 Nm	3000 Nm
Weight	approx. 155 kg	approx. 165 kg

Model plate (affixed to gearbox housing)

ZF FRIEDRICHSHAFEN AG
MADE IN GERMANY

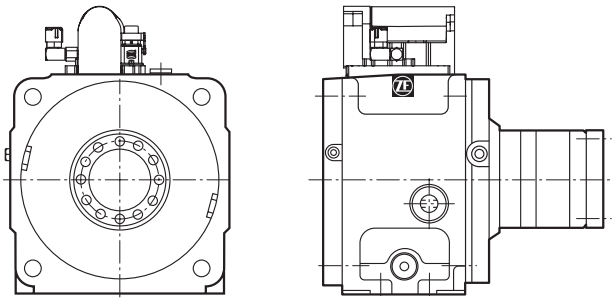
TYPE _____ PARTS LIST____ _____ _____
RATIO i _,__- _,__ SERIAL-NO._____
BACKLASH MAX. ____ MIN. INPUT TURN _____ RPM
POWER MAX. AT____ RPM ___ KW
INPUT TORQUE _____ NM OIL GRADE _____
SHITING _____ V OIL
UNIT ____ W QUANTITY _____





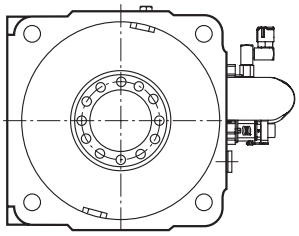
2.5 Installation positions

Horizontal B5

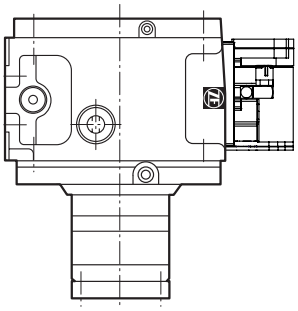


Horizontal B5

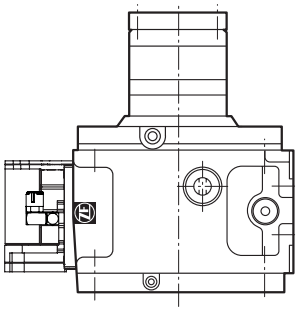
Shift unit on right side,
gearbox turned around
longitudinal axis
(view to output end)



Vertical V1



Vertical V3



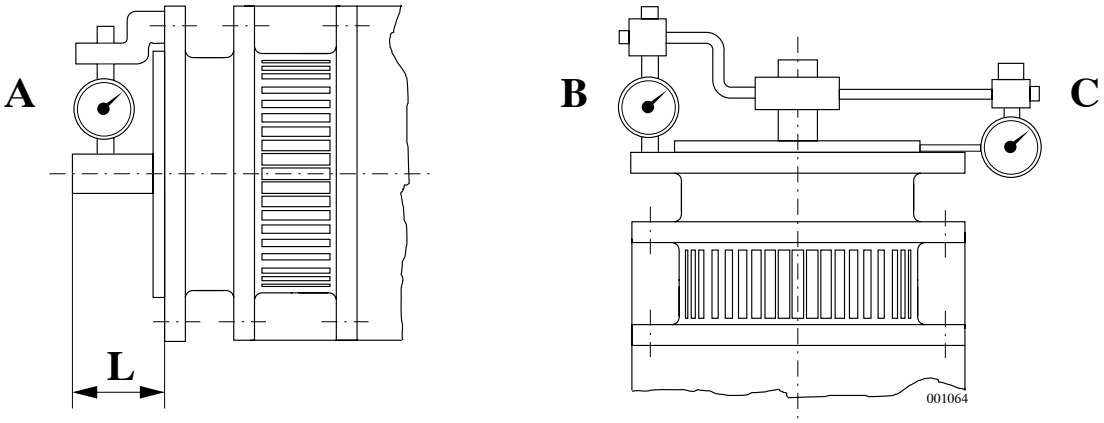
CAUTION
The breather outlet must always be at the top,
regardless of the installation position.

3 Initial Installation

3.1 Axial runout, radial runout and length tolerances – drive motor

In order to guarantee fault-free operation, the motor must not exceed the specified tolerances.

Take into account the motor shaft elongation caused by heating in motors with fixed bearing on the B-side (opposite the motor output shaft).



Axial runout, radial runout and length tolerances – electric motor mounting flange:

Gearbox type	Tolerance			
	A	B	C	L
2K450/ 2K600	0.025	0.063	0.063	- 0.200

Tolerances A, B, C to DIN 42955R
Please note that the tolerance of the shaft length "L" is restricted in relation to the DIN standard

CAUTION
The special tolerance for shaft length "L" must be maintained in order to guarantee fault-free gearbox operation. Undersize shafts must be compensated for by using shims when mounting to the motor. Oversize shafts must be machined to the correct length.

Take into account the permitted axial forces on the motor shaft. Also see ZF-DUOPLAN catalogue (4161 750 102), "Performance data" chapter.

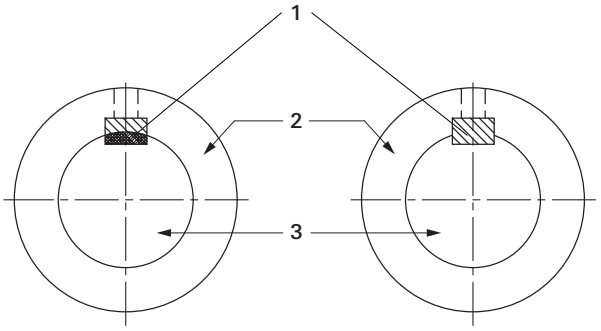
3.2 Balancing

The hubs (2) come with a keyway (1) for transmitting power from the motor shaft (3) as standard.

There are two balancing types for the motor and gearbox: Semi-key and full-key, which are described in more detail in DIN ISO 8821.

It must be ensured that the hub is balanced in the same way as the motor.

This is why it is very important to indicate the motor data, dimensions and balancing type when ordering.



Half-key balancing Full-key balancing

Motor output shafts with standard fitted key in accordance with EN 50347: 2001

Shaft diameter	Fitted key	Fitted key length
55 mm	A16x10	90 mm
60 mm	A18x11	125 mm
65 mm	A18x11	125 mm

NOTE
In the case of motor shafts with open ends of the keyway, the parallel key is to be glued into the groove in order to avoid axial migration of the parallel key and/or the hub.

3.2.1 Semi-key balancing

In semi-key balancing, the keyway is filled with a balance compensation corresponding to approximately half a key, shape B by default. This is based on the original key, shape, length and position used by the motor manufacturer and is defined as a counterweight. In semi-key balancing – in contrast to full-key balancing – the joint passes through a shared component. This means imbalance can arise after assembly due to tolerance factors.

As a result, it is recommended that rebalancing should be performed after the joined parts have been assembled.

3.2.2 Full-key balancing

In full-key balancing, the motor shaft is balanced with a full key whereas the hub is not. The key, shape, length and position are not important in this case.

3.3 Adaptation, motor/gearbox

The motors must have a flange-mounting option for mounting the gearboxes.

The gearbox housing is fitted to the motor by means of the centering adapter on the bearing housing. This is standard.

There is also a foot mounting on the gearbox housing for 2K450 and 2K600.

Different gearbox variants are used depending on the motor type. Gearbox mounting also differs accordingly.

Reference dimensions for hub position

Gearbox type	Dimension D in mm
2K450	175.5-0.2
2K600	175.5-0.2

CAUTION
In the case of motors with fixed bearing, on the B side, the dimension is D = 175.0-0.2.

Spacer discs are supplied with shims of varying thickness. These enable balancing of the motor shaft length tolerances and, therefore, compliance with reference dimension “D”.

3.3.1 Open design

The open version is the gearbox without adapter plate but with seal on the motor output shaft (2) to prevent gearbox oil ingress.

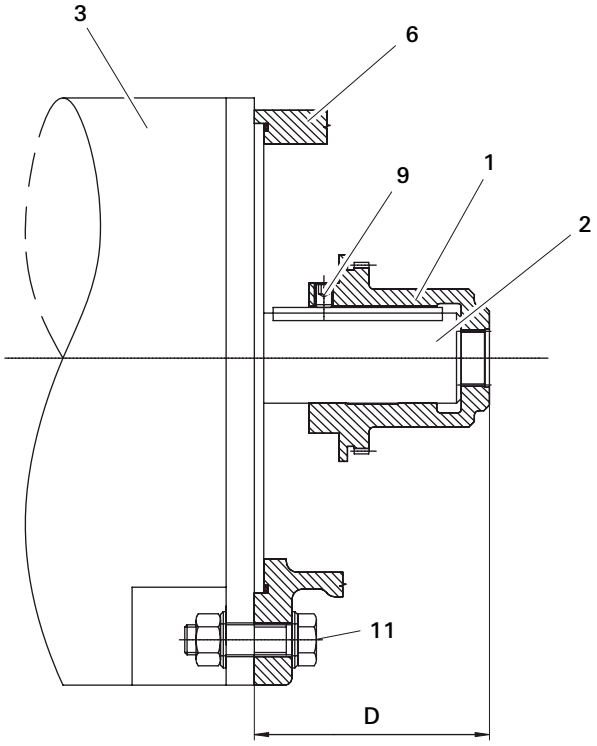
The drive hub (1) is delivered loose with the gearbox. Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft for concentricity, axial runout and length according to chapter 3.1 and correct as necessary. Use shim rings to compensate undersize. Shorten the motor shaft in case of oversize. Also lightly grease the motor shaft.

After cleaning the fitting surfaces, heat the drive hub to approx 120 °C from the opening and slide it onto the motor shaft until it reaches the stop.

Then check reference dimension “D”.

CAUTION
Risk of motor shaft damage if the hub is not sufficiently heated.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 3.4.



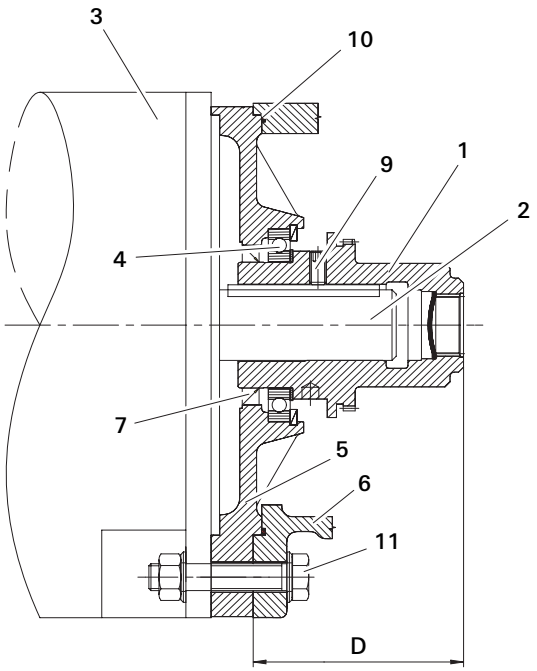
3.3.2 Closed design with hub bearing and shaft sealing ring

Variant with ball bearing (4), in which the hub (1) is also mounted in bearings to prevent axial hub migration.

When assembling, separate the drive hub (1) with adapter plate (5) from the gearbox housing (6). Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft (2) for axial and radial runout as described in chapter 3.1. Also lightly grease the motor shaft.

After cleaning the fitting surfaces, heat the drive hub to approx 120 °C from the opening and slide it onto the motor shaft until it reaches the motor flange stop.

Reference dimension “D” is set at the factory.



CAUTION
Risk of motor shaft damage if the hub is not sufficiently heated.

NOTE
When assembling, it must be possible to easily slide the hub onto the motor shaft until the adapter plate is against the motor flange.

CAUTION
Do not use the adapter plate to help slide the hub onto the motor shaft.

Check by ensuring that the fitted adapter plate can be turned freely. This ensures that there is no hub bearing preload.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 3.4.

NOTE
The radial shaft sealing ring in the drive motor must be removed on the output end when the closed design is used.

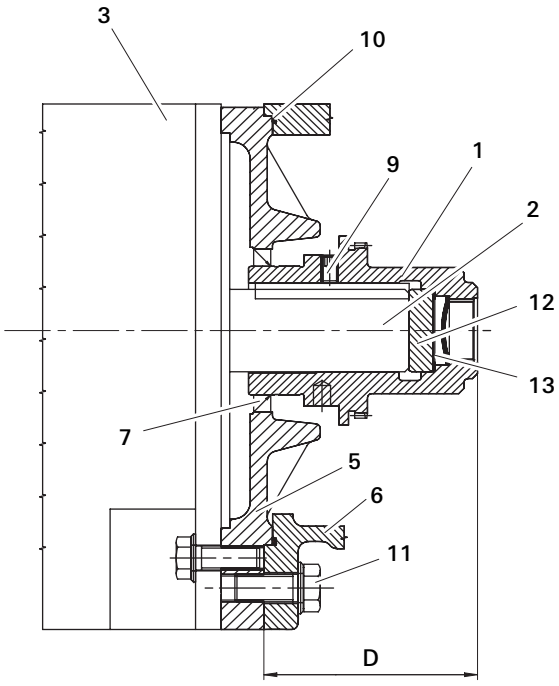
3.3.3 Closed version (with shaft seal)

This variant incorporates an adapter plate (5) with shaft seal (7), which means that the gearbox forms a compact, closed unit.

The adapter plate and drive hub (1) are separately delivered loose. Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft for axial and radial runout as described in chapter 3.1. Also lightly grease the motor shaft (2).

After cleaning the fitting surfaces, place the adapter plate with radial shaft seal onto the motor housing. Heat the drive hub to approx 120 °C from the opening and slide it onto the motor shaft until it reaches the stop, i. e. spacer disc (12) with shims (13).

Then check reference dimension “D” and change using shims if necessary.



CAUTION
Risk of motor shaft damage if the hub is not sufficiently heated.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 3.4.

CAUTION
Thoroughly grease the radial shaft seal and the drive hub before installation. When installing, make sure that the sealing lip and the radial shaft seal are in the correct position.

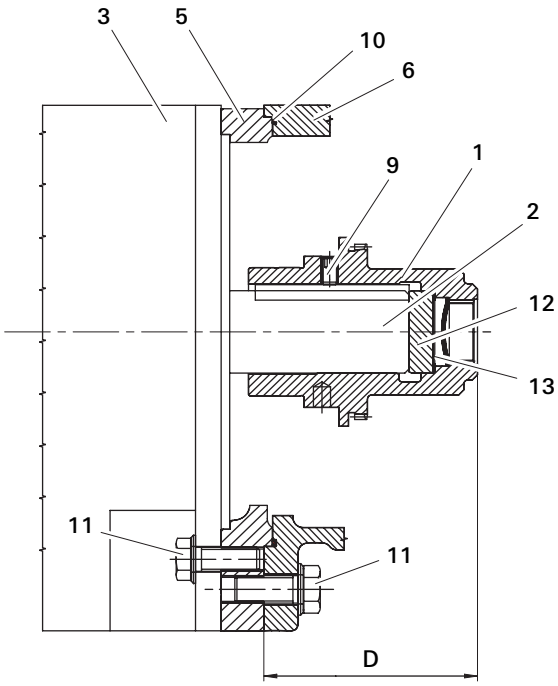
3.3.4 Open design with adapter ring

The adapter ring allows adaptation to different connection dimensions. A seal is required on the motor output shaft.

The adapter ring (5) and drive hub (1) are delivered loose. Clean the fitting surfaces of the motor (3) and drive hub. Check the motor shaft (2) for axial and radial runout as described in chapter 3.1. Also lightly grease the motor shaft.

After cleaning the fitting surfaces, place the adapter ring onto the motor housing. Then heat the drive hub to approx. 120 °C from the opening and slide it onto the motor shaft (2) until it reaches the stop, i. e. spacer disc (12) with shims (13).

Then check reference dimension “D” and change using shims if necessary.



CAUTION
Risk of motor shaft damage if the hub is not sufficiently heated.

Tighten the threaded pin (9) and secure it to prevent it from turning, see chap. 3.4.

3.3.5 Version with pulley drive

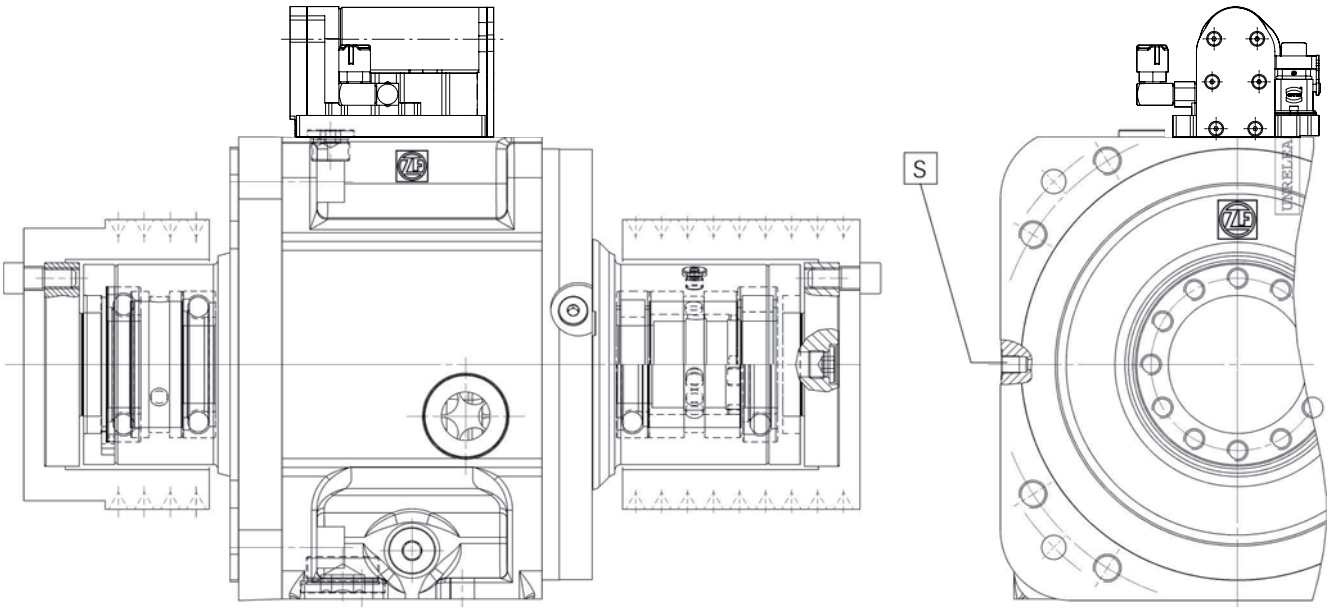
The pulley will be centred on the outer diameter of the drive flange (K6 tolerance), friction-locked in place and secured using screws, whereby the permitted torque must be taken into account.

The pulley must have a balance rating of 6.3, as per VDI Directive 2060, in order to ensure low vibration operation.

It is mandatory to lubricate the bearings fitted in the pulley drive with 0.5 – 1.0 l/min via oil connector 'S' in the drive housing.

CAUTION
The stipulated maximum tensioning strength must not be exceeded when the belt is tensioned in order to prevent the bearings from being overloaded.

The average belt power must lay in between the bearings. The pulley must be just touching the drive flange when fitted; heat up the pulley if necessary.



3.4 Gearbox – fit

The M8 set screw (9) must be screwed in and tightened at the parallel key with 18 Nm until firmly home. Make sure you coat the threaded pin with liquid seal before installing it.

Make sure that the O-ring (10) is in the correct position during installation. The O-ring is delivered loose with the gearbox and has to be coated with grease before being inserted into the seal groove in the housing (6).

Check the position of the gearbox shift mechanism. The sliding sleeve must be in the 1st gear position ("low" gear ratio).

Take up the gearbox and place it onto the motor flange. Carefully bring the sun gear/hub connection together when doing this.

NOTE
The external spline of the sun gear must be guided into the internal spline of the hub.

This can be made easier by turning to the left or right at the gearbox output.

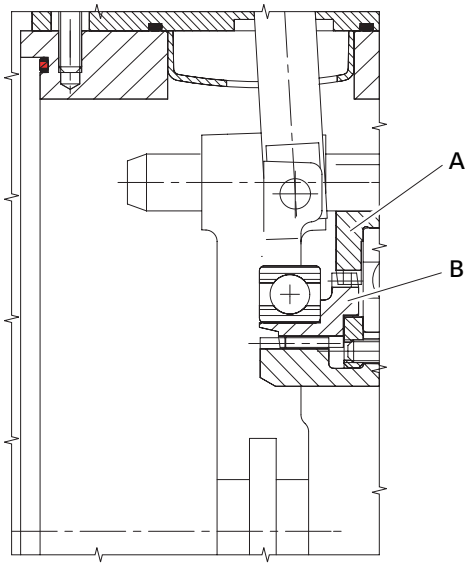
The gearbox housing, adapter plate and motor are bolted together using four/eight hexagon bolts (11).

Fill the gearbox with oil and connect up the recirculating lubrication system and the power supply. The breather outlet must always be at the top, regardless of the installation position. Tighten by max. 1 turn if necessary. The breather is screwed in to the B5 position ex-works.

The gearbox is now ready for use.

CAUTION
The gearboxes can be operated under the same degrees of protection as those defined for AC and DC motors.

When setting up, make sure that the motor cooling air can flow in and out unhindered.



1st gear position:

A Brake disc
B Sliding sleeve

NOTE
Before taking the electric motor/gearbox assembly into operation, check that the gearbox output can be turned by hand.

In the case of drive units that are fixed on the gearbox flange or housing, the motor can be supported on the B-side so that it does not vibrate.

3.5 Output

3.5.1 Version with belt output

The belt pulley must be centered on the outer diameter of the output flange (tolerance K6), fastened with the bolts so that it is frictionally engaged and secured. Comply with the specified tightening torques.

The belt pulley should be balanced to quality 6.3 as per VDI Directive 2060 in order to ensure low-vibration operation.

CAUTION
Note the maximum specified tensioning force when tightening the belts in order to prevent bearing overload.
The average belt force must be between the bearings. When assembling, it must be possible to easily slide the belt pulley onto the output shaft. Heat the belt pulley if necessary.

3.5.2 Version with coaxial output

In the case of the version with coaxial output (shaft stub), also note the balancing type for the output (see chap. 3.2). The gearbox is delivered with full-key balancing.

Refer to the installation drawing for the fitted key dimensions. Always fix the fitted key using a threaded pin.

3.5.3 Version without output

The output shaft is not supplied by ZF. It is manufactured by the customer. Refer to the installation drawing for a proposal of how the connection point for the output shaft should be configured with the DIN 5480 profile.

3.6 Electrical connection, gearchange

The gearbox is electrically connected using the supplied 8-pole Harting connector (HAN 8 U). The plug-in connection is located on the shift unit.

3.6.1 Shift unit

Technical data:

Standard and neutral position	120 W
Supply voltage	24 V DC ± 10 %
Power consumption	5 A
Index of protection	IP64

The required cable lead diameter is 1.5 mm².

The 24 VDC connection voltage and 5 A power consumption must be assured on the shift unit connector.

Losses due to cable length and transition resistors must be taken into account.

Scope of supply:

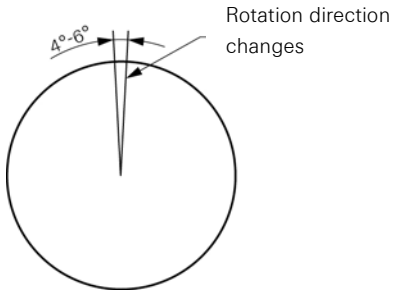
Sleeve housing, screw connection, socket insert and 8 jacks, type Harting AWG16. The shift unit can only be obtained as a complete part.

Gearbox shift mechanism:

Gearchanges are effected when the 24 V voltage is applied to pin 2 and 3. The polarity of the applied 24 V DC voltage dictates which gear is engaged.

In 1st gear => Pin 2: + / Pin 3: –
In 2nd and 3rd gear => Pin 2: – / Pin 3: +

During the gearchange, the main spindle motor should make the shaft oscillate ±5° at a rate of 1 to 5 rotation direction changes per second. Major pendulum motion may lead to damage at the meshing gears.



In average, this means: n_{Mot} = 5°/s = 5° 60/min = 300°/min = 300/360 rpm = 0.83 rpm.

Conversion
Pendulum speed ↔ pendulum rotary motion

Speed [rpm]	Angle [°/min]	Time [sec]	Angle [°/sec]
0.25	90	3.33	5
0.50	180	1.67	5
1.00	360	0.83	5
2.00	720	0.42	5
3.00	1080	0.28	5
4.00	1440	0.21	5
5.00	1800	0.17	5

The machine optimum is to be determined on the basis of shift tests in relation to the different masses and thereto connected drag torques of the spindle.

The limit switch signals from S1 (contact 4) and S2 (contact 6) serve to shut off the shift unit once the gearchange is complete.

CAUTION
After the limit switch signals have been reached, the shift unit is allowed to be live for a maximum of 0.5 second. The limit switch signals must be monitored during the operating time.

The limit switches must only be energized with the control current (0.1 – 0.5 A) and not with the changeover current (5 A).

If the number of resistors is rather small, also a lower control current can be used.

The control current for end-position monitoring is to be set according to length, line and transition resistance and the number of connection points. Increased resistance due to corrosion after some time must be taken into consideration.

If the limit switches detect that a gear is no longer securely engaged, steps such as emergency shut-off etc. must be initiated through the control system.

NOTE
Electromagnetic fields can falsify the limit position monitoring currents. This can be prevented by re-routing or shielding the line.

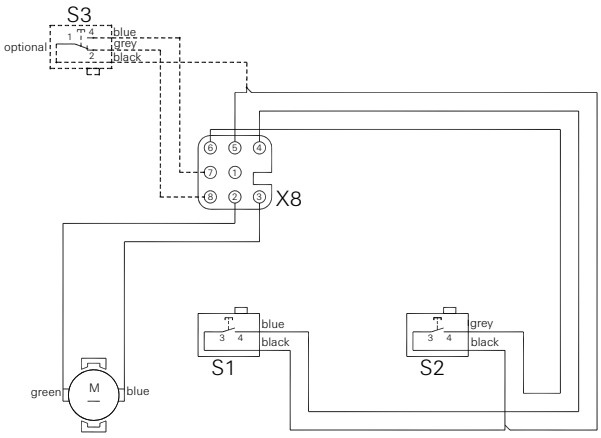
The shift sequence must be monitored. If necessary, a timer should be used to cancel the shift sequence after approx. 2 seconds if there is no limit switch signal (S1/S2). The main spindle motor can not be operated until this signal is present.

Diagram for shift unit with two positions (standard) or three positions (with neutral position):

1st gear ==> e. g. 4:1

2nd gear ==> 1:1

3rd gear ==> S3 neutral position, idling (option)



The electromotive gearchange is performed by a shift unit on the gearbox which is driven by a DC motor (24 V DC). The gearbox shift element is a positively locking, axially movable selector fork that acts on a sliding sleeve.

The limit positions are monitored by limit switches in the shift unit. The time sequence is monitored in the control unit.

The motor must be energized when shifting from gear 1 to 2 or vice versa. The direction of rotation is changed over by reversing the polarity.

NOTE

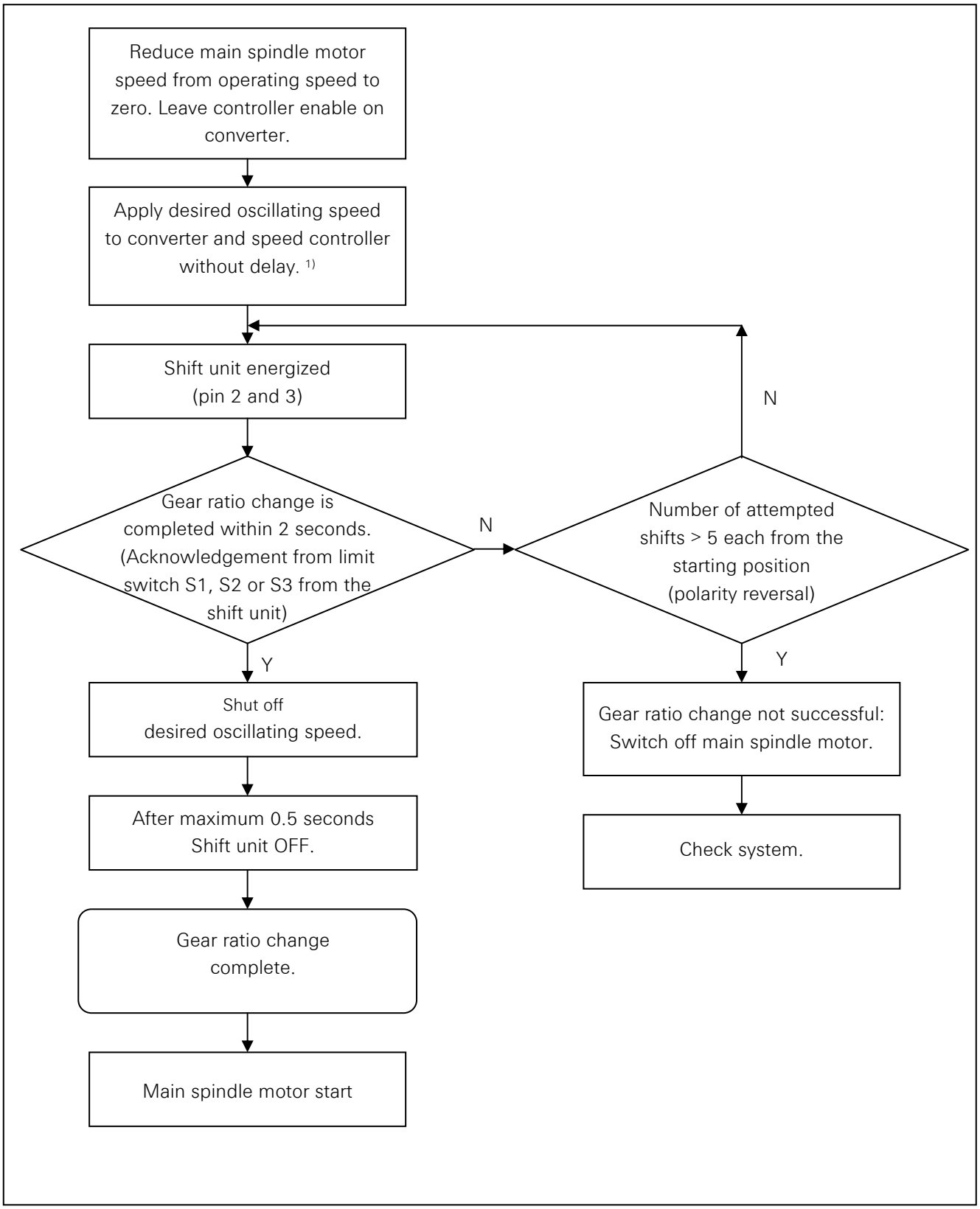
Gearbox with neutral position

The neutral position can only be reached via gear 1.

As soon as limit switch S3 receives the signal, the DC motor must always be switched off using a regenerative motor stop (Quickstop).

Under certain operating conditions (e. g. installation orientation V3, higher cable resistance values), it may be necessary to have a variable timing element in the control unit → contact ZF.

3.6.2 Shift logic


Reduce main spindle motor speed from operating speed to zero. Leave controller enable on converter.
Apply desired oscillating speed to converter and speed controller without delay. 1)
Shift unit energized (pin 2 and 3)
Gear ratio change is completed within 2 seconds. (Acknowledgement from limit switch S1, S2 or S3 from the shift unit)
N
Number of attempted shifts > 5 each from the starting position (polarity reversal)
N
Y
Y
Shut off desired oscillating speed.
Gear ratio change not successful: Switch off main spindle motor.
After maximum 0.5 seconds Shift unit OFF.
Check system.
Gear ratio change complete.
Main spindle motor start

1) Alternatively, the first switching test can be performed without oscillating, but this requires a de-energized main spindle motor or minor output-end masses.

3.7 Lubrication

3.7.1 Splash lubrication

The standard B5 version of the gearbox has splash lubrication.

CAUTION
Splash lubrication is suitable for intermittent operation. In this instance, frequent gearchanges, varying speeds and idle time (e. g. due to retooling) are the order of the day.

The gearbox oil must be filled up to the middle of the oil sight glass in such applications.

The actual oil level is all-important when it comes to filling up with oil. The quantity in liters indicated on the gearbox model plate is intended as a guide only.

NOTE
If the gearbox is installed at an angle – as is the case in certain belt tensioners – an oil level tube with calibration mark must be fitted in place of the oil sight glass.

The oil level in the gearbox must be the same as for a gearbox installed in horizontal position (also see installation drawing).

3.7.2 Recirculating lubrication

CAUTION
Recirculating lubrication is required for continuous operation, for operation in one gear ratio over an extended period of time, for high speeds and for intermittent operation with shorter idle times, regardless of the installation position.

Recirculating lubrication is required for 2K450/2K600 gearboxes installed in the vertical V1 (output downwards) and vertical V3 (output upwards) positions. In this instance, the type of recirculating lubrication depends on the operating temperature level required.

The centrifugal forces acting on the oil can lead to insufficient lubrication of the gearing during continuous direct-drive operation.

Occasionally changing gear (ratio) and then starting the motor (n_{Mot} = 1000 rpm) supplies oil to the gearing and prevents one-sided, position-specific loading of the gearing.

Some applications require a very low operating temperature level which can be reached by connecting an adapted gearbox oil supply with oil cooling. The respective gearbox versions are prepared accordingly.

The gearbox has different ports and connections for recirculating lubrication – depending on the installation position and the operating type – in order to ensure optimum gearbox cooling without affecting lubrication.

The diagrams on page 25 show the oil inlet and outlet points on the gearbox. Please refer to the relevant installation drawings for precise details.

Following the initial startup, the oil level must be in the middle of the oil sight glass when the gearbox is at standstill. Top up the oil if necessary.

CAUTION
The pump, oil tank and heat exchanger components must be arranged below the gearbox oil level. Connecting an oil return as described in chapter 3.7.3.2 assures limp-home (emergency control) characteristics.

NOTE
The following incidences are no cause for concern:

- The oil level in the tank falls due to foaming of the gearbox oil in the gearbox during operation.
- An oil-air emulsion is formed in the oil return and in the tank.

3.7.2.1 Recirculating lubrication for V1/B5 operation

Refer to chapter 3.7.2 for the position of the oil inlets and outlets.

The oil supply is mounted on the central connection point T M12x1.5 and, in case of hub bearings, connection point M M10x1. The total oil supply rate should be between 2.0 and 2.5 dm³/min.

For the oil return flow, an oil sight glass is removed and an outlet pipe (M42x1.5) is screwed in instead.

In the V3 vertical installation orientation, the gear oil can also be supplied centrally via the output shaft connection P.

The outlet line should be dimensioned so as to prevent oil return blockages in the gearbox (D_i approx. 20 mm).

3.7.2.2 Recirculating lubrication with heat exchanger

A heat exchanger is installed in the recirculating lubrication system to ensure additional temperature reduction.

3.7.2.3 Recirculating lubrication with intermediate tank

The tank volume should be at least ten times the recirculating oil quantity in order to ensure effective oil cooling.

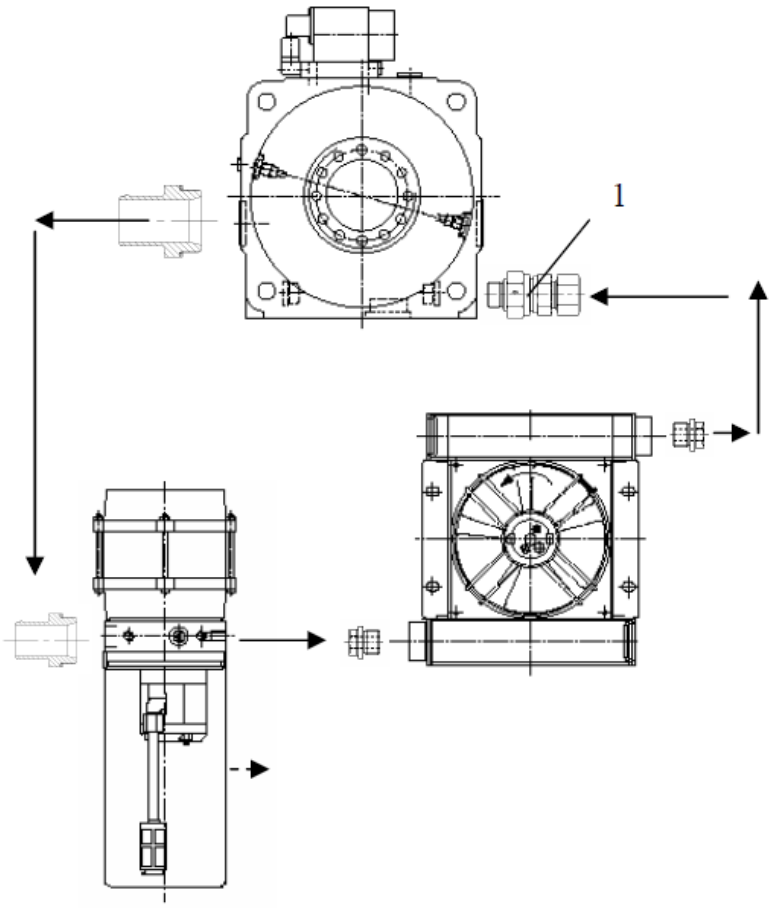
NOTE
An oil level sensor on the intermediate tank is recommended in order to prevent damage to the gearbox due to dry running.

A 60 µm filter and a safety non-return valve (1) must be used at the gearbox oil inlet.

This arrangement ensures continued operation based on the splash lubrication, see chap. 3.7.1.

The oil return line must always lie below the oil outlet downstream of the gearbox to ensure that the oil level in the gearbox does not rise.

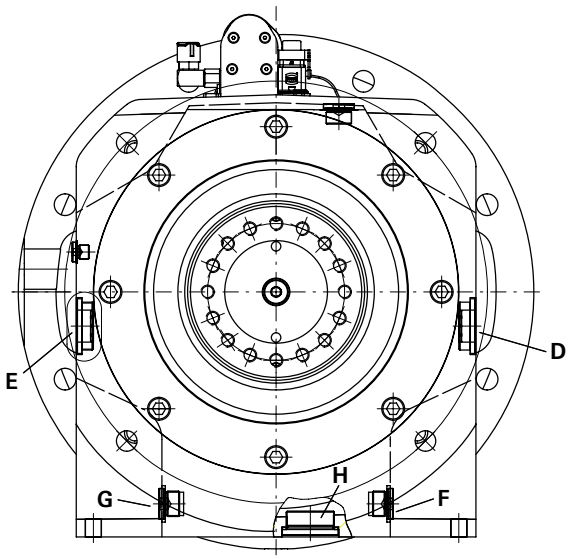
Installation example B5

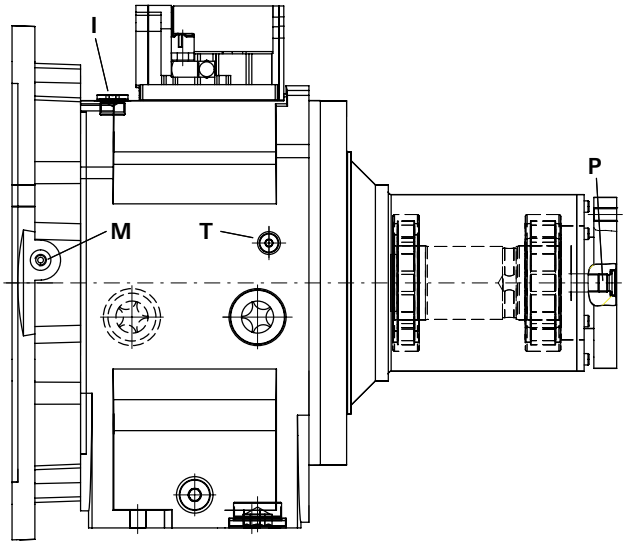


3.7.3 Ports and connections for lubrication

3.7.3.1 Ports and connections for initial fill/oil change

Installation position	Oil fill	Oil drain
B5	I	F, G, H
B5 rotated		D
V1		P (for version with output flange)
V3		D





3.7.3.2 Connections for circulating lubrication in standard applications

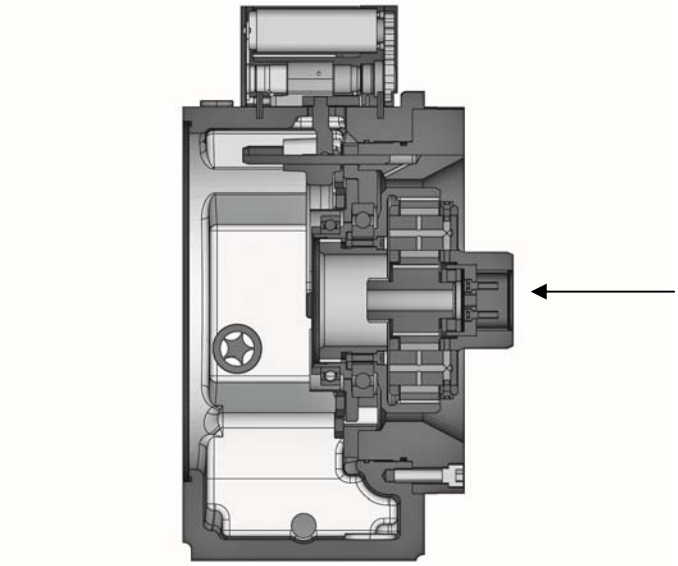
Installation position	Oil inlet port	Max. pressure	Oil return port
B5 (open variant)	G (2.0 dm³/min) Main rotation direction counter-clockwise* F (2.0 dm³/min) Main rotation direction clockwise * or T (2,0 dm³/min)	1.5 bar 1.5 bar 0.5 bar	D Main rotation direction counter-clockwise * E Main rotation direction clockwise *
B5 (closed variant)	M (1.0 dm³/min) and T (1.5 dm³/min)	0.5 bar 0.5 bar	
B5 gedreht (open variant)	T (2.0 dm³/min) or I (2.0 dm³/min) or F (2.0 dm³/min) or G (2.0 dm³/min)	0.5 bar 1.5 bar 1.5 bar 1.5 bar	H
V1 (closed variant)	M (1.0 dm³/min) and T (1.5 dm³/min)	0.5 bar 0.5 bar	E
V1 (open variant)	T (2.0 dm³/min)	0.5 bar	E
V3 (closed variant)	M (1.0 dm³/min) and T (1.5 dm³/min)	0.5 bar 0.5 bar	D
V3 (open variant)	T (2.0 dm³/min)	0.5 bar	D

* As seen facing gearbox output

NOTE: The principal factor in determining the oil supply volume is always the volume that flows out of the oil return. In the case of transmission with belt pulley drive, consider the additional lube oil bore “T” (also refer to Chapter 3.3.5).

3.7.3.3 Connections for recirculating lubrication for direct mounting on the headstock

Take account of connection M acc. to chapter 3.7.3.2 for the oil supply. Implement the oil return according to the installation orientation.



Oil supply in all installation orientations 2 l/min

4 Taking into Operation

4.1 Initial inspection

Check that the gearbox is correctly installed before taking it into operation.

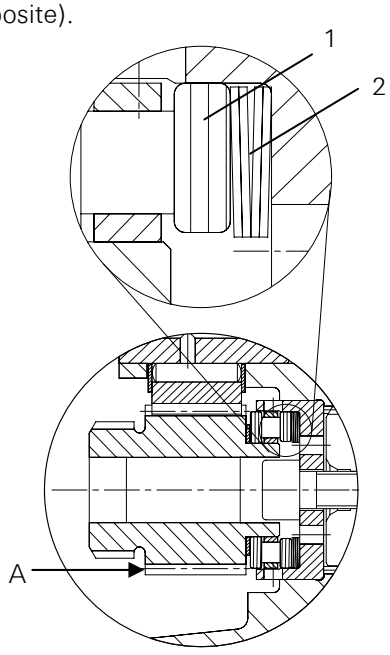
- Mechanical fastening
- Motor flange-mounting
- Gearbox oil ports and connections
- Oil supply/oil fill assured
- Electrical connections
- Ease of movement (can be turned by hand)
- Breather vertical position

4.2 Sun gear setting – check

Check dimension “A”: 175.7 mm, tolerance +0.2 mm, measured between the housing connection surface and the front end of the sun gear. When measuring, press the sun gear towards the output until it reaches the stop.

The sun gear is correctly set before leaving the factory.

Check the dimension after inserting the sun gear, e. g. following disassembly. Dimension “A” is correct if the spring pack (2) and shims (1) are fully and correctly installed (see detail illustration opposite).



5 Maintenance

5.1 Oil change

Oil change interval: Every 5000 operating hours

⚠ ENVIRONMENTAL HAZARD!
Lubricants and cleaning agents must not be allowed to enter the ground, the water table or the sewage system.

- Request safety information for the products concerned from your local environmental protection authority and follow any instructions herein at all times.
- Always collect used oil in a suitably large container.
- Always dispose of used oil, clogged filters, lubricants and cleaning agents in accordance with environmental protection laws.
- Always observe manufacturer instructions when dealing with lubricants and cleaning agents.

Drain used gearbox oil into a suitable container if it is at operating temperature.

The drain ports differ depending on the installation position and gearbox version (see chap. 3.7.3.1).

Pour new gearbox oil through port I.

The oil level is deemed correct when it reaches the middle of the oil sight glass when the gearbox is idle.

The oil level itself is all important. The oil quantity in liters indicated on the model plate is a reference value only.

If available, let the oil pump operate briefly after filling with oil to remove any air and top up with oil again if necessary.

6 Repair

In the event of gearbox malfunctions, first check the connected components and their ports and connections.

Carefully document the type of fault so as to assist manufacturer diagnosis (see chap. 6.1).

Repairs on the gearbox itself may only be carried out by ZF Friedrichshafen AG or by authorized ZF after-sales points.

6.1 Gearbox fault checklist

If you encounter drive unit faults, please refer to the remedies in chapter 7 first of all for help.

If this does not solve the problem, you will need to provide the following information for diagnosis at ZF Friedrichshafen AG or an authorized ZF after-sales point:

Gearbox data on the model plate

Typ: . . .
(Type)

Stückliste: 4161 . . . . . .
(Parts list no.)

Serien-Nr.: . . . . . .
(Serial no.)

Motor data on the model plate

Manufacturer: . . .

Type/size: . . .

Questions for fault diagnosis:

- Is gearbox oil sight glass dark/discolored black?
- Smell of burning oil at oil breather?
- Gearbox running noise in 1:1 or 4 (5):1 gear ratio, or only in one rotation direction or in both rotation directions?
- Before the running noise occurred, was the machine operated in only one gear ratio (1:1) for an extended period of time?
- Did the running noise occur after changing the machine's cycle or was the machine cycle unchanged?
- Was any maintenance carried out on the machine before the fault occurred and, if yes, what did this maintenance work involve?
- No gear change or gear loss in the event of a shift problem?
- Does shift logic conform to ZF specifications (see page 22)?
- What is the shift unit voltage during the shift sequence?

6.2 Gearbox – disassemble

(e. g. version with adapter plate, shaft seal and hub bearings)

Proceed accordingly in the case of other versions.

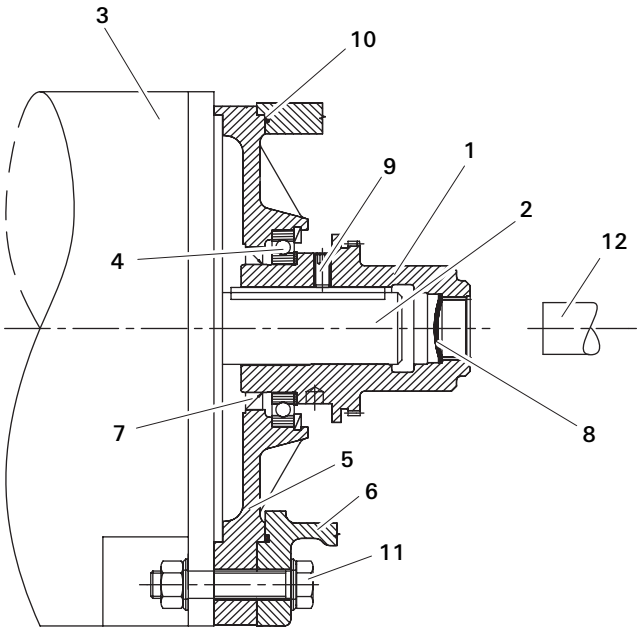
- Switch off the machine
- Switch off the power supply
- Disconnect the electrical connections
- Disconnect the gearbox oil connections, drain the gearbox oil
- Undo the mounting bolts (11)
- Pull the gearbox (6) off the adapter plate (5) and drive hub (1)

6.3 Hub

- Undo the threaded pin (9) used to radially secure the fitted key.
- Use a removing device, e. g. three-arm puller, to pull off the drive hub against the motor shaft without heating the hub:
  Press off against a removing aid (12) on the cover (8). Keep turning the puller until the cover is at the spacer disc/motor shaft.

CAUTION
When disassembling the hub, ensure that the cover (8) is centred on the motor shaft. Otherwise the cover may cause the hub to jam when being pulled off.

Renew the end disc 40 DIN 470 after disassembly. Clean before installing and coat the sealing edge with liquid seal. Visually check the shaft seal and O-ring and fit new ones if necessary.



1 Drive hub
2 Motor shaft
3 Motor
4 Hub bearing
5 Adapter plate
6 Gearbox housing
7 Shaft seal
8 Cover
9 Threaded pin
10 O-ring
11 Mounting bolt
12 Removing aid
(cylinder ⌀ 25x100 mm)

7 Frequently Asked Questions (FAQ)

Error	Cause of error	Remedy
Gearbox is loud, knocking noises	• Loose contact on motor speed sensor, which causes permanent motor governing • Speed sensor dirty, no clear signals sent	Check speed sensor and electrical lines to motor, clean speed sensor if necessary. Check engine management system, adjust speed control accordingly (softer setting).
Gearbox is loud, running noise	Long periods at high cutting speed in ratio 1:1 followed by change to machining in ratio 4:1	No gearbox damage Gearbox running noise normalizes after several gear changes.
	Axial bearing incorrectly installed	Check installation.
	Shims/spring washers on sun gear incorrectly installed	Measure reference dimension “A”.
Gearbox is loud, running noise in ratio	Motor shaft is too long, axial bearing damaged	Check reference dimension “A”, correct and install new bearing if necessary.
Gearbox leaking at gearbox input/output	Defective seals	Renew seals, send gearbox to ZF for inspection if necessary.
Gearbox leaking at breather	• Oil has aged • Too much oil added during oil change	• Change the oil. • Check the oil level and correct if necessary.
Machine control receives no shift position signals from the gearbox shift unit	• Loose contact in the plug connection on the gearbox shift unit • Error in the shift unit	• Check the plug connection and clean if necessary, secure connectors using clips. • Send gearbox to ZF for inspection.
Gear disengages	• Limit position switch defective	• Send gearbox to ZF Friedrichshafen AG for inspection.

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